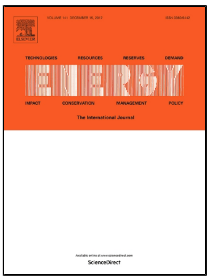
Accepted Manuscript



Dynamic modeling and operation optimization for the cold end system of thermal power plants during transient processes

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PII:	S0360-5442(17)32189-8
DOI:	10.1016/j.energy.2017.12.146
Reference:	EGY 12095
To appear in:	*Energy*
Received Date:	15 June 2017
Revised Date:	28 October 2017
Accepted Date:	27 December 2017

Please cite this article as: Chaoyang Wang, Ming Liu, Yongliang Zhao, Yongqiang Qiao, Daotong Chong, Junjie Yan, Dynamic modeling and operation optimization for the cold end system of thermal power plants during transient processes, *Energy* (2017), doi: 10.1016/j.energy.2017.12.146

Dynamic modeling and operation optimization for the cold end system of thermal power plants during transient processes

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Abstract: This paper focuses on the dynamic modeling of the cold end system of a thermal power plant and its operation optimization during cycling load processes. A revised logarithm mean temperature difference is recommended to calculate the heat transfer quantity between exhaust steam and condenser tubes. With this method, a condenser model is developed with a maximum relative error limited within 3%. Coupled with a turbo-generator, a condenser, water pumps, and a cooling tower, a closed cooling system model is established. The total power supply (TPS) during cycling load is calculated and analyzed to optimize the operation during transient processes. A method for obtaining the maximum value of TPS is provided and used to calculate the optimal operating load rate points for switching pumps (OPSP). OPSP increases with the cycling load rate (V_e) during loading up processes decreases with V_e during loading down processes. When V_e is identical, OPSP declines with the ambient temperature for the loading up and down processes. TPS during transient processes is relevant with the switching pump load rate. The maximum value of difference in TPS with different switching pump periods is 691.4 (kW h) for switching pump numbers from 3 to 2 during loading down processes.

Keywords: Thermal power plant; Cold end system; Dynamic modeling; Cycling operation; Energy consumption

1. Introduction

1.1. Research background

At the background of conventional energy crisis, dynamically developing renewable sources is a long-term policy for humans. However, electricity generated from renewable sources, such as wind and solar energy, is variable, partly unpredictable[1, 2], and operation mode of conventional power plants varies between maintaining the long stationary running state and frequent cycling operation to compensate for and reduce the gap between electricity demands and generated power from renewable sources [3-7]. In other words, the cycling load operation mode for coal-fired power plants is a new norm in China. Ensuring the stability and safety of electricity is incumbent for thermal power plants. Cycling load transient processes remain for approximately 50 minutes from one steady state to another. The frequent cycling load operation and long transient time necessitate the focus on dynamic behaviors and energy characteristics of thermal power plants. In recent decades, the performances of power plants during transient processes have attracted a considerable amount of attention and interest from researchers. Specific applications include the optimization of control strategies, stress assessment for critical components, and the plant safety analysis in malfunction cases [8]. However, studies on energy saving during transient processes has been limited, which makes the research on energy characteristic during dynamic processes necessary and essential.

1.2. Literature review